Dual layer Delay Tolerant Networks (DTN)for Congestion Control

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Abstract: DualLayerDelay Tolerant Networks is a new method to give better reliability and increase the efficiency of the network. Commonly Delay Tolerant Networks (DTNs) are coupled different nodes irregularly, so packet transferring in this type of networks are time consuming and nodes are scattered here and there. Communication under sea, space communication, management of calamity, tracking animals are some applications of DTN. For these types of communication we need to arrange a sensor node, which capable to maintain consistency in the presents of any environmental changes. Using Machine Learning method provide a better lifetime, through that it can provide solution for many of current issues. Machine Learning in Delay Tolerant Network assists, proper mapping of path by adjusting to the Node arrangement variations, moderatesovercrowding, and decreases unexpected issues. This paper provides an improved method of ML techniques use with DTN. In my knowledge, this work is one of the best method to solve DTN real-time problems with ML techniques. Nowadays neural network have an important role to solve many problem facing in Delay Tolerant Networks.

Keywords: Delay Tolerant Networks, neural networks Machine Learning, Routing and Congestion control

1.   Introduction

Delay tolerant networking is an approach to computer network architecture that seeks to address the technical issues in heterogeneous networks that may lack continuous network connectivity. Communicating from Earth to any spacecraft is a complex challenge, largely due to the extreme distances involved. When data are transmitted and received across thousands and even millions of miles, the delay and potential for disruption or data loss is significant. Delay Tolerant Networking (DTN) is solution to reliable internetworking for space missions. DTN manages three communication networks consisting of distributed ground stations and space relay satellites for data transmission and reception. From low-Earth orbit to deep space communication, it has used point-to-point or single relay links to communicate with spacecraft. Future exploration concepts will introduce much more complex communication needs, with data transfer between many nodes. These transmissions will need to operate like the Internet here on Earth – involving multiple hops via relay spacecraft and other intermediate nodes (like as Fig1), creating the foundation for a Solar System Internet.

Examples of such networks are those operating in mobile or extreme terrestrial environments, or planned networks in space. Because of environmental factors, network will not have continues connection from beginning to end.Thus the current node need to keep the data packet in a temporary memory space up to that, it gets the information of next node to the terminal point. All the node, in between this path repeats this activity up to that the data packet reaches in the terminal node. Astronomical data transferring, Wireless device data transferring, Subway system data transferring, Collapse controlling system, object tracing in wild area are some of the applications of Delay Tolerant Network.

A *DTN* is a network of challenged-networks that support long delays and data loss between and within challenged networks, with the potential for countless. The routing in outdated communication systems, initially creates the routes between the Network stations, before the real data transfer begins, which confirms consistent network connections. Because of scattered distribution of nodes, it will be difficult to create a complete route for a delay tolerant network We can't store any general network protocol for DTN, in this we are using store then forward method [1]. Each network station keeps the data packets up to that it gets the information of next network station, which is receiver node or near to receiver.

Machine Learning is a part of AI, teaches the structure to acquirenew information from the previous experience and update with present system. Recently many new applications are created to solve our real-life problems with the help of Machine Learning. Image recognition is a well-known and widespread example of machine learning in the real world. Speech recognition-Machine learning can translate speech into text. Medical diagnosis, Statistical arbitrage, Predictive analytics.DTN is a computer networking method, which consist of instructions for Data transfer , also called as protocol suite, that improve the global Internet abilities into the challenging communication atmospheres in space where the conservative Internet does not perform well. These

situations are typically subject to frequent disturbances, links that are limited to one track, probablytime-consuming and unacceptable fault rates.

DTN: A general-purpose network-/transport-layer service offered by DTN, which is logically same as TCP/IP, provides for the terrestrial Internet. DTN suitable for use in the space environment communication. In DTN implements basic store-and-forward method for internetworking service.The main features of DTNareefficiency, consistency, safety, duplicate overthrow,prioritization, distant management, rate buffering, and data accounting, all over feasibly irregular and time-disjoint paths. Several applications including file transfer, messaging and streaming audio-visual can all be applied on top of DTN and influence its service area to shrink threats, budget, and complication.
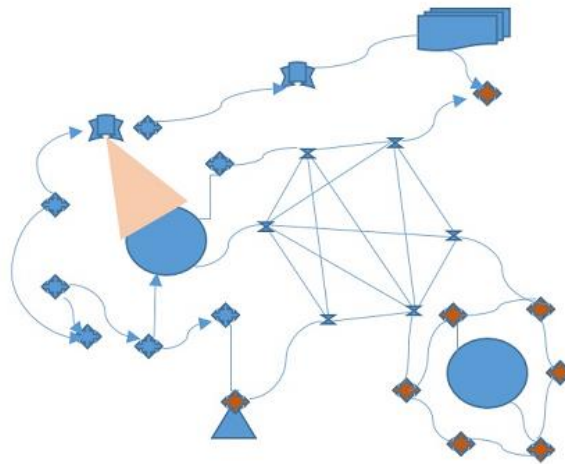

Fig: 1 Solar System Internet.

The remaining paper is discussing, the role of machine learning in network communication. The challenges faces in DTN communication. New method to improve performance of DTN with the help of Machine learning.

2.   Machine Learning Algorithms

In general, Machine learning can learn from data, identify patterns and make decisions with minimal human intervention. So ML uses for data analysis that automates analytical model building. Still, many methods we can develop to improve routing mechanism, reduce congestion, reduce complexity … etc. Altogether fourteen types of Machine learning methods are there, out of this supervised learning method train thestructureusing the set of labelled data in a proficientway.Unsupervised learning builds the model, which trains with unlabeled dataset. The resemblance between the information extracting from the dataset is used to shape a new method.Reinforcementlearningtrains the structure to collect information from environment communication, then learn it.

2.1. Supervised Learning:

A set of labelled data is using to train the existing system is called Supervised Machine Learning The set of input data categorised into suitable labels, which it belongs to. If the data is repeated again and again in the system, then that model learn, how to categorize these dataset by matching available set of labels.

K-Nearest Neighbour (KNN): Commonly test data names to adjoin data set, with labelled training dataset. Euclidean distance algorithm is using to handle wave type data streams and hamming distance algorithm use to handle Binary type data stream, through that it calculates and find out the nearest Neighbour. In K-Nearest Neighbour Algorithm, Routing decision is taken by considering the time index, starting point, Ending point and the status of packet delivery.

Neural Network: The SLA is a multilayer learning algorithm, which has many layers, In that each layer contain n number of nodes, and these nodes are connected with preceding and succeeding layers[3]. Many hidden layers are packed in between input layer and output layer, in this Input layer is the first one. The effect of the node with next layer characterized the weight of the interconnection with that layer. In hidden layer, each node has astimulation procedure, it shows activation percentage of particular node. In this paper [4], MLProph method (Machine Learning to improve Prophet routing algorithm) includes neural networks , it consider favoritefactor, reliability , throughput , memory capability, hop liveliness, total number of hop, etc as some of the input values.

Also two outcomes that are percentage of possibility to deliver a packet and percentage of possibility to fail delivery a packet.
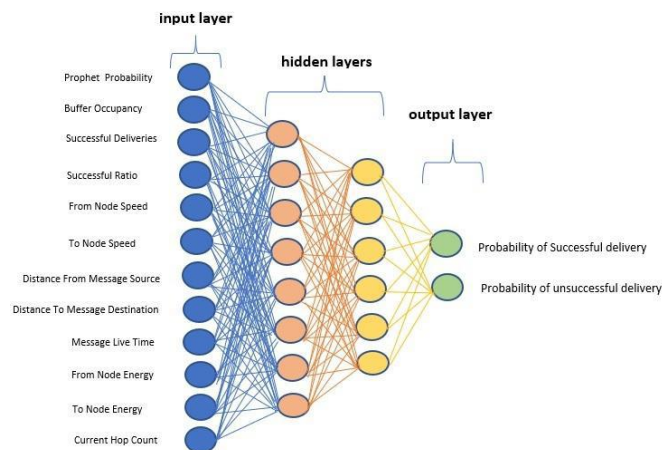

Fig. 2. A Sample Neural Network

Fig 2. Shows the basic communication in Neural Network, in this calculated value of each node is the direct mixture of the calculation of previous layer nodes. Backpropagation method uses to provide training datasets, through that acquirecorrespondingweightage of each hop of present network layer to all nodes of upcoming layer. With Artificial Neural Networks, the next node and time required to reach in that node is predicted [14], [15]. Present node ID, start time , end time , prior node ID, start time from prior node are the 5 input factor in neural network. Training is conducting by Backpropagation method. Artificial Neural Networks implemented in Trust based Intelligent Routing method to evaluate and learn the trust values of the nodes, through that constructing a smart routing decision [21]. Time Variance among Latest Connection and Previous Connection,Occurrence of Calls,Total Period are the three factors use to develop a trust function. The Liquid State Machines (LSM) with Spiking Neural Networks, can calculate ideal next node at the time of network routing [23]. Define the activities of each neuron by The Leaky-Integrate-and-Fire (LIF) neuron model. Randomly select twenty percentage Neurons as interdict, then balance eighty percentage as recitative. An ideal next hop is the output of a SNN with ten input neurons

An algorithm can calculates and tags while data is frequent through a conditional tree is called decision tree [5]. The decision unit in the decision tree, comparing the different types of dataset factors at the time of iteration through the decision tree, by consider the condition of each node to subsequent node, it makes an exact label for the data in the query. Correct clipping of the decision tree is compulsory, then never the training data disturb the classification. A sample decision tree displayed in Fig. 3.
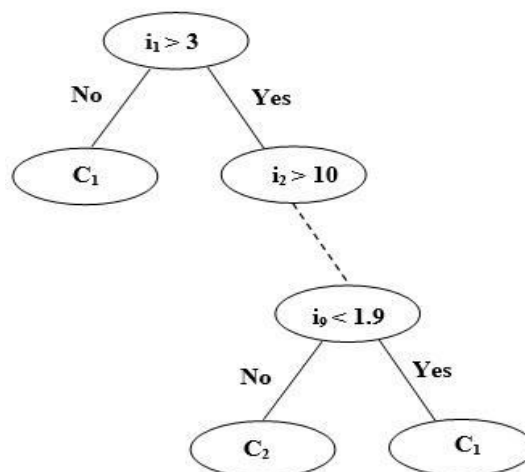

Fig. 3. A simple Decision Tree

Probability of successful delivery calculates using twelve input factors in the MLProph method with the help of decision tree [4]. With respect to the conditions, each node labelled or lead to the next suitable node, this process starts from root node to destination. Decision implements recursive function and uses training data.

In DTN vehicular networks, decision tree method is using at the time of routing to reduce the complexity [6]. Whether the packet transfer to next hop or not decide by the algorithm, by considering the values of Distance, travel time, received time, lobby index, area code, node ID. Which are the input values use to build decision tree.

Data Dissemination Algorithm, is a new algorithm to control congestion in delay tolerant network. Interpersonal energy, similarity, expectation of refinement to increase the data transfer possibility and centrality are new factors suggested by this algorithm [22]. To achieve the desired objective, decision tree help to select the values of each factors. Decision tree give a collection method to select the ideal values for the above elements, to get a satisfactory performance.

Bayesian Classifier: It is a simple algorithm with least set preparation data to surmise the arrangement using supervised learning. Imagine X is first action and Y is second action, according Bayes theorem the subsequent possibility of X, probability $(X|Y)$ directly proportional to $P(X) P(Y|X)$, and $P(X)$ is the previous possibility of X and $P(Y|X)$ is the possibility of detecting X from specified Y [7]. This method has a disadvantage, which is requirement of prior distribution.

FSF protocol is another method to control congestion in DTN. Full form of FSF is friendship & acquaintanceship forwarding. Naive Bayes Classifier is used to categorize nodes in the networks like friends, acquaintances, and unknowns. The number of meetings, meetings outside the University are the attributes, used in MIT research experiment, through this they develop a database. Bayesian classifier differseach meeting pointas "distributive" & "non-distributive" for the following node in the direction of destination, also calculate subsequent probability using Time slot, area code and other input values [9]. Bayes Theorem use to calculate affiliation index, this value choose the node, when the question arising which is the next node.

In the Naïve-bayesian approach, it guess the consistency of next node with the help of these factors – that are average inbound data forwarding rate , outbound rate, requests, inaccuracy rate in bits, distance…[10]. Support Vector Machine is controlled teaching technique, which use to categorize information with the help of labelled preparation information set [18]. In DTN malware detect by Support Vector Machine, so this SVM will train with trained sample data in Naïve-Bayes [19].

2.2 Unsupervised Learning:

Machine learning method, which use to categories the data with the help of similarity based method is called unsupervised method. Any types of training don't include in unsupervised learning. K-Means Clustering method collects the information from dataset centered on the unsupervised training [11].

Steps of K-Means Clustering

Step 1: Select K meeting points randomly, from the centre of constellation.

Step 2: Each meeting point, calculate the adjoiningaxis using distance function.

Step 3: The new axis are decide by membership of present meeting point

Step 4: Stop this procedure when the confluence is touched else move to step 2

Recognize the areameeting points in the network connect frequently by K-means clustering algorithm, with respect this gathering, the meeting points are clustered for advance arrangement [2]. Another method, which wrapping different types of information also decreases scopes by converting connected information into at right angles is called PCA (Principal Component Analysis). Principal Components are the factors which are unconnected [16]. Based on influencing factors, which are the resources need at the time of emergency forecasts by Principal Components Regression, in post disaster [17]. Based on influencing factors, which are the resources need at the time of emergency forecasts by Principal Components Regression, in post disaster [17]. After Principal Component Analysis, these influencing factors are selected and converted into Principal components (PC).

2.3 Reinforcement Learning

Reinforcement Learning is a type of machine learning, which directs the software agents to make a series of moves requiring skill and care, to make best result of specified situation. Quality-Learning is an Ideal strategy to pick an action that intimate, what action should be select by mediator to produce best performance, for present situation. In Markov Decision Process, Quality -learning by identifying the Situations(S), Activities(A), Situation

changeover Possibilities(P) and Results(R) scored for a present Situation and select an optimal stroke, is called as a Tuple [S, A, P, R]. The Step decision Policy make by meeting points in the Q- Learning Algorithm, using it's analysis ability. While analyzing the selected action, it will be dissimilar of existing steps select for the similar situation. While in taking advantage of the new action and the present action is same, then the beginning exploration is useful.

QDTR is a Delay Tolerant Networks routing procedure based on Quality learning, which converts many problems of path finding underwater to a Markov Decision Process for using quality learning algorithm [12]. Through this conversion the group of interconnected computer consider like a system. The specified packet transfers to the next connected point with respect to the situation. While an information reach to the destination, that state is called terminal state or highest state of that data transfer. The data transmission procedure select the best way to touch destination, through that it can provide maximum throughput. Throughput depends on some elements and the weightage of these elements. The elements are travelling distance to destination, data rate in network and the residual power of next hop. By changing the weightage of these elements QDTR can improve throughput of the system.

Quality learning method use to soften network traffic through Smart Delay Tolerant Networks for congestion control[13]. In SDTNCC, for all possible states, q-values maintained by each node in the network in a q-table, also it maintains every imaginableactivities (a) for a specific step(s) & Q(s,a) the process and corresponding step. The efficiency of node to control congestion by estimated q-values. This algorithm observe the environment and values of the influencing factor of previous methods, then find a new policy to improve the performance. The Boltzmann probability distribution is used to discover the optimal actions, in that WoLF technique is used.

Quality-learning method is used to memorise the optimal connectiontoneighbors [10]. In this, rebroadcasting work of a specific node keeps in memory & weightage of the node is constant then increase weightage of that node. Then the same node use for upcoming data transfer through that route and move to terminal node.

DQLR uses distributed way to select the next hop [21].it expands as Double Quality-Learning Routingalgorithm. DQLR considers the election and valuation individually by different functions, so it is called double Quality-Learning function. These two programsanalyses all messages of each meeting point, then decide next node. In this one function value depend to another function value. The data packets in the meeting point acquire by the action-worth algorithm and with respect to the best result, coming node is decided for the existing meeting point, to transfer that data packet.

DTRB method practices multiple proxy reinforcement Learning. Delay Tolerant Reinforcement-Based can improve performance through acquire the routing information &duplicatedata packets [24]. Reward provides by an information exchange and displacement information stored in control information, which interchange by the nodes of the network. Each meeting point keeps the performance information in tabular form, which contains Q-values, initially Q-values are zero. At the time of routing present node send and expected result to the neighbour nodes. Based on this message, neighbour node updates its estimate with same control message. In this method traveling distance from sender to receiver inversely proportional to the performance.

3.   Challenges in DTN

Routing: In Bayesian classifier routing method, a node meets multiple neighbour nodes, then this node compute the affiliation index of each neighbour node [9]. So in this which neighbour node have high affiliation index is selected as following node.

Friendship & acquaintanceship forwarding uses Naive Bayes classifier to find out connections of each meeting point by categorizingit'scommunication information with other nodes as companions,associates, and stranger [8]. In FSF, a node forwards the packets to friend nodes and acquaintance nodes. But it doesn't communicate with a strange node.

In MLProph, it predicts the node capability to deliver the packet successfully by computing MLProbability, which is calculate with the help of Neural network and Decision tree method [4]. Simulations reflects that, it provide an improved throughput.

In QDTR algorithm, implemented quality learning method, so this one is flexible and efficient path finder[12]. It can achieve reduction in memory overhead, Increment in delivery rate, energy efficiency and minimise end to end delay by adjusting the weight of the influence factors. In Hybrid Machine learning, it using Graph routing method to adjust with all network parameter changes [10]. For neighbour nodes, reliability prediction calculated by the Naïve Bayesian Classifier. Utilisation of the consistent neighbour nodes done by Q-learning approach, so it can used for feature communication. , Decision Tree method, the Naive Bayes method, and K-Nearest Neighbour method are the supervised learning method use to select next node from a group of neighbour nodes. In this,

Decision tree is providing better performance than other types K-means clustering algorithm. In TBIR method, calculated trust values help to select routing decision [21]. At the end of this paper, develop a solution for the different types of Delay tolerant network challenges by Machine Learning Techniques. The routing resolution is centred on the last link or node, when an intermediate node and destination node have equal trust value. If the trust values of end point node is very high then it will select intermediate node for routing.

Channeling Overhead Management: Decision tree method categorizesneighbour nodes to m different class. In this Epidemic routing algorithm and SaW algorithm are used to decrease the routing complexity. In flooding-basedtransmitting, overhead is reduced by retransmission probability of vector V. $V_i$is the packet forwarding possibility of aninformation set to a meeting point of class C. Class of a meeting point and packet transmission possibility is inversely proportional. In SaW method, for reducing overhead, it sprayed maximum of L copies. In this low class nodes selects as next node in the network.

Congestion Control: The level of congestion in the node predict by Smart-DTN-CC by exploits the local information. Prospective-congestion, Decreased-congestion, Non-congestion and Congestion are the different states of a node. When a node change it's status from Congested to Non-Congested or Partially Congested to Decreased Congested state, then the result will be positive value. If the Non-Congested to Congested or Decreased Congested to Partially Congested then the result value will be negative. So the result value always in between 1 and -1. So the system can be flexible with state changes.

4. Dual Layer DTN

In this paper I would like to propose a method through that can a node can improve it's congestion control mechanism. As a beginning, we know that in DTN network commonly data transfer will happened in large scale. So we need a better method to send data to the destination. In this paper we already discussed the problems like routing, routing overhead, reliability issues, security issues, and congestion control

So In this I am presenting a method to improve reliability and congestion control in DTN network. When we consider the scenario we are considering some factors which are effecting the performance of a node at the time of routing, that are arriving rate, Queuing Probability that depend on processing rate and congestion in the path. Queue upphilosophydiscusses to the mathematical study of the creation, function, and overcrowding of waiting lines, or queues. A queuing situation includes two slices. Sender or node that appeals a service and next hop or destination that finalizes or provides the service like data transfer.

As per the Kendall notation queuing hops are categorized with the symbolization A/S/c/K/N/D where:

- ➢ A is the arrival data packet
- ➢ S is the measuredsharing of the routinginterval
- ➢ c is the total hops
- ➢ K is the queue size of the node, dropped if unlimited
- ➢ N is the totalimaginable packets, dropped if limitless
- ➢ D is the queuing method, with FCFS

In this DTN packet arrival process like as the Poisson process, in this λ is the packet arrival rate in unit time, δ is time interval and p is probability of packet is come to node, and n = number of arrivals in T, through this we can calculate processing rate.

$$P(n \text{ arrivals in interval } T) = \frac{(\lambda T)^n e^{-\lambda T}}{n!}$$

In Duel Layer DTN, nodes collect status in each interval, repeat all these steps sequentially so always have a list of best routes with each router, in this DTN movement of node is also important factor which is effect the performance, so through this method we can ensure better reliability than other algorithms but it create more memory overhead. Also it provide better data transfer than SCC DTN. So it can control congestion better than Smart congestion control method.

Duel Layer DTN Algorithm

Step 1: Select x number of node using ML method

Step 2: Send a query packets to all neighbour nodes

Step 3: Using Poisson Process, Node calculates probability

Step 4: Calculate processing rate of node

Step 5: Collect info packet from each neighbour

Step 6: Sort info packet with respect to the higher probability

Step 7: Select first two neighbour nodes

Step 8: Send data through it and get an ACK from two nodes

Step 9: From the ACK select the optimal path with ML method

From Fig 4 (graph) we can understand that Dual layer DTN Method provide better performance than other three methods, it also provide better reliability than other three methods like Praphet+, Decision Tree and Neural Network. Dual layer DTN provide better throughput than these three methods. So we can show that Dual layer DTN is providing better performance in reliability and efficiency than other methods. But in this method memory requirement will be more than other method that is a drawback, when we compare with other methods. Including the features of Neural Network method and Machine Learning concept, it is providing more reliable performance than other methods. Memory is not a big concern, when we consider reliability and throughput of this method. The new technology will find a solution for this memory overhead.
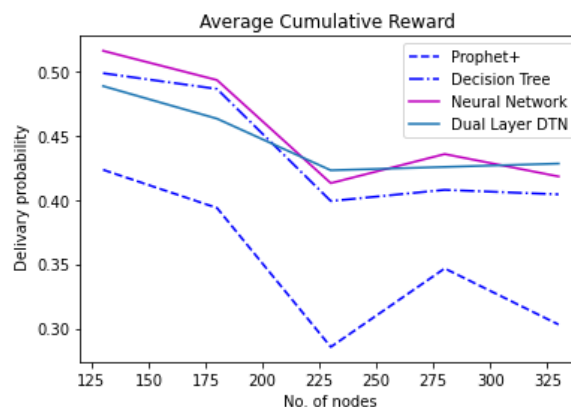

Fig. 4

In Fig. 4 graphically represent the performance comparison of four types of delay tolerant network method. Also in tabular method explaining the performance of different algorithms. From this we can recognize that Dual layer DTN providing better through put when the number of nodes are increasing. In the Fig.4, this graph is representing diagrammatic representation of this table. X axis, represents total node we consider and Y axis represents delivery possibility of each situation.

No. of Nodes	130	180	230	280	330
Prophet+	0.4233	0.3937	0.2857	0.3467	0.3031
Decision Tree	0.4983	0.4861	0.3990	0.4077	0.4042
Neural Network	0.5157	0.4930	0.4129	0.4355	0.4181
Dual Layer DTN	0.4883	0.4630	0.4229	0.4255	0.4281

Table 1: Data from The ONE Simulator

5.   Comparison Of Different Active Delay Tolerantnetworks Algorithms

SL. NO.	Method	Advantage	Disadvantages
1	**K-Nearest Neighbour**	Simple, Robust, Updating overhead is less	Sensitive to the scale of the data, Require high memory
2	**Neural Networks**	**Having fault tolerance, Having a distributed memory, Ability to make machine learning, Parallel processing capability**	Hardware dependence, **The duration of the** network is **unknown**

3	**Decision Trees**	Reduce routing overhead , easy to explain, requires less effort for data preparation	higher time to train the model, expensive
4	**K- Means clustering**	Scales to large data sets, Guarantees convergence, Easily adapts to new examples.	Difficult to predict K-Value.
5	**Principal Component Analysis**	low noise sensitivity, increased efficiency, Less memory	Demand forecasting, confused with the incorrect value of constant, fails to reproduce the original behaviour
6	**Duel layer DTN**	Increase efficiency, increase reliability, **Ability to make machine learning, Parallel processing capability**	More memory usage, Hardware dependence

Table.2 Advantage and Disadvantage of Different DTN Method

6.   Conclusion

All current DTN routing algorithms cannot be applied well in countryside circumstances, we propose a DCAR algorithm. Delay tolerant networks are Special network, distinct from general networks. So many variety of problems are facing in the area of DTN. Solutions are developing by different algorithms with the help of new technologies also try to apply new logical variations of parameters to sort out some of these problems. Machine Learning is an advanced technology we can use in DTN. This approaches can be support to improve network changes, proficiently route the packets, decrease different types of overhead and help to do control network traffic [25].

Machine Learning methods are precise in estimation, congregate very fast, understand the present environment from the previous experience, so it is very useful to preserve liveliness and resources in Delay Tolerant Network. DTN is an area which didn't use all ML possibilities. So DTN can utilize different type of machine learning techniques more better way. Many Artificial Intelligence techniques can be used in Delay Tolerant Network, to find the solution for Non-functional and functional challenges, like Information accretion, incident recognition and query handling, interference discovery system, excellence of service, error Finding, etc.

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